UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

ECOLOGICAL SITE DESCRIPTION

ECOLOGICAL SITE CHARACTERISTICS

Site Type: Rangeland

Site Name: Sandy

Site ID: R042XB012NM

Major Land Resource Area: 042 - Southern Desertic Basins, Plains, and Mountains

Physiographic Features

This site usually occurs on level to gently sloping or undulating piedmont slopes or plains. Slopes range from 1 to 15 percent, averaging less than 10 percent. Elevations range from 3,800 to 5,000 feet.

Land Form: (1) Pediment
(2) Plain

	Minimum	Maximum
Elevation (feet):	3800	5000
Slope (percent):	1	15
Water Table Depth (inches):	N/A	N/A
Flooding:		
Frequency:	Very rare	Rare
Duration:	Extremely brief	Very brief
Ponding:		
Depth (inches):	N/A	N/A
Frequency:	None	None
Duration:	None	None
Runoff Class:	Negligible	Very low
Aspect:	No Influence on this site	

Climatic Features

Annual average precipitation ranges from 8 to 10.5 inches. Wide fluctuations from year to year are common, ranging from a low of about 2 inches to a high of over 20 inches. At least one-half of the annual precipitation comes in the form of rainfall during July, August, and September. Precipitation in the form of snow or sleet averages less than 4 inches annually. The average annual air temperature is about 61 degree F. Summer maximums usually exceed 100 degrees F. and winter minimums can go below zero. The average frost-free season exceeds 200 days and extends from April 1 to November 1. Both the temperature regime and rainfall distribution favor warm-season perennial plants on this site. Spring moisture conditions are only occasionally adequate to cause significant growth during this period of year. High winds from the west and southwest are common from March to June, which further tends to create poor soil moisture conditions in the springtime.

	Minimum	Maximum
Frost-free period (days):	179	212
Freeze-free period (days):	200	233
Mean annual precipitation (inches):	8.0	10.5

Monthly precipitation (inches) and temperature (°F):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Min.	0.37	0.36	0.23	0.18	0.29	0.57	1.42	1.92	1.53	1.01	0.48	0.57
Precip. Max.	0.54	0.39	0.27	0.36	0.45	0.64	1.9	2.2	1.66	1.07	0.58	0.78
Temp. Min.	20.8	25.5	31.2	38.0	46.4	54.3	61.1	59.1	51.5	39.8	28.8	22.3
Temp. Max.	58.1	63.8	71.0	79.3	87.4	96.4	95.5	92.7	87.5	78.7	67.2	58.5

Climate Stations:
(1) NM3855, Hatch. Period of record 1961 - 1990
(2) NM8387, Socorro. Period of record 1961 - 1990

Influencing Water Features

This site is not influenced by water from a wetland or stream .

Wetland Description: (Cowardin System)	System	Subsystem	Class

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Representative Soil Features

The soils are moderately deep to deep and well drained. Typically, the surface layer is a fine sandy loam, sandy loam, to loamy fine sand more than 5 inches thick over medium or moderately fine textured underlying layers of soils having fine sandy loam or sandy loam over moderately coarse-textured underlying layers. The soils have moderate to moderately rapid permeability with moderate to high water holding capacity and are capable of storing winter moisture for early spring growth by certain forbs and grasses. Effective rooting depth is often 60 inches or more, although adequate moisture is seldom available to make use of this for most plants. Note: Soil Reaction figures 1.8 below are minimum figures required by this program and are not accurate.

Predominant Parent Materials:
Kind: Eolian deposits
Origin: Mixed-igneous-metamorphic & sedimentary

Surface Texture:	(1) Fine sandy loam	
	(2) Sandy loam	
	(3) Loamy fine sand	
Subsurface Texture Group:		Sandy
Surface Fragments <=3" (% Volume):		0
Surface Fragments > 3" (% Volume):		0
Subsurface Fragments <=3" (% Volume):		5
Subsurface Fragments > 3" (% Volume):		0
Drainage Class:		Well drained To Excessively drained
Permeability Class:		Moderately slow To Moderate

	Minimum	Maximum
Depth (inches):	20	60
Electrical Conductivity (mmhos/cm):	0	4
Sodium Absorption Ratio:	0	0
Calcium Carbonate Equivalent (percent):	0	0
Soil Reaction (1:1 Water):	6.6	8.4
Soil Reaction (0.01M CaCl2):	N/A	N/A
Available Water Capacity (inches):	1.0	7.0

Plant Communities:

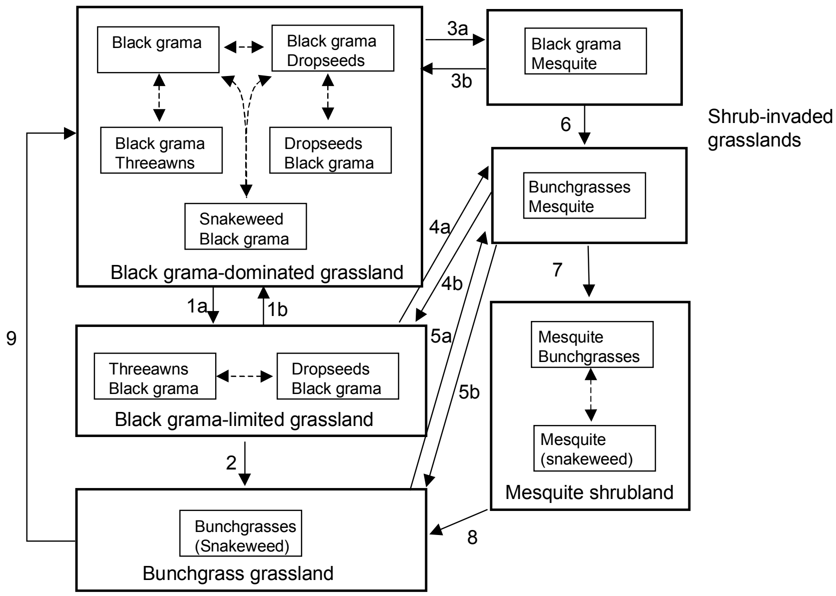
Ecological Dynamics of the Site

Overview

This site may exist as a finely-scaled mosaic with the Shallow Sandy site depending on local variation to the depth of caliche. This site may also intergrade with the Deep Sand and Gravelly Sand sites. Frequently, the mesquite shrubland state of this site, including the development of coppice dunes, has been associated with the Deep Sand ecological site (c.f. soil series in Hennessy et al. 1983). The Deep Sand site is a distinct ecological site harboring soils and vegetation that developed long before the coppice dunes. The historic plant community type of the Sandy site is dominated by black grama (*Bouteloua eriopoda*) and other grasses, especially dropseeds (*Sporobolus* spp.). Natural spatial variation in the vegetation of this ecological site may be governed by slight variations in soil texture. For example, dropseeds may dominate on loamy sands. Variation in the depth to a restrictive horizon, such as caliche, may also drive variation in grass cover. Black grama is a key plant of this site due to its dominance under pristine conditions, its high forage value, and its consequent sensitivity to grazing. Shifts away from black grama dominance are thought to be due to overgrazing and/or multi-year periods of summer or spring drought, or due to the introduction of honey mesquite (*Prosopis glandulosa*) seeds with or without grazing. With continuous heavy grazing, the proportional representation of black grama declines because it is preferred by cattle over dropseeds, threeawns and snakeweed (*Gutierrezia* spp.; Paulsen and Ares 1962). Dropseeds are more palatable than threeawns, so dropseeds may also decline relative to threeawns and snakeweed. Under climatic conditions that are not conducive to black grama reproduction, or due to the loss of components of the soil biota, demographic limitations may lead to persistent absence of black grama, even without shrub invasion. Shrub invasion is, however, very common. Loss of soil stability and/or a reduction in black grama cover may permit either the survival or establishment mesquite seedlings due to reduced competition or fire frequency. Subsequent grazing by livestock and native herbivores, competition from shrubs, erosion, and concentration of nutrients under adult shrubs eventually leads to persistent reductions of grass cover and mesquite-dominated coppice dunes with bare or snakeweed-dominated interdunal areas.

A substantial number of studies exist that document states and potential causes of transitions. There are multiple competing and complementary explanations for individual transitions that have not been formally tested. If the operation of these mechanisms is case-contingent, it may be especially problematic to define the causes of transitions quantitatively (e.g. a threshold cover of black grama). Nonetheless, careful monitoring of black grama health should be a key feature of management in SD-2. Overall, the high palatability of black grama during times of year when most other species are less palatable, coupled with the limited capacity of this grass to regenerate under current climatic conditions (Nielson 1986), leads to a relatively high probability of transition with poor range management. It is also possible that changes in climate over the last several hundred years have created an SD-2-wide transition from the presumed historic plant community type and that good management can only delay the inevitable shift to mesquite shrubland.

State-Transition model: MLRA 42, SD-2, Upland sandy site group: Sandy



1a. Climate change and/or overgrazing, moderate soil degradation. **1b.** Restoration of soil fertility (if climate not involved)
2. Extinction of black grama, severe soil degradation.
3a. Introduction of mesquite seeds, reduced grass competition, lack of fire. **3b**.Shrub removal, restoration of fuel loads and fire.
4a, **5a**. Mesquite invasion. **4b**, **5b**. Shrub removal, restoration of fuel loads and fire.
6a. Black grama extinction due to mesquite competition and grazing. **6b.** Shrub control with black grama restoration.
7. Continued grass loss (e.g. overgrazing), inter-shrub erosion, soil fertility loss, high soil temperatures, small mammal herbivory. **8**. Dune destruction, mesquite removal, soil stabilization, nutrient addition, seeding during wet periods.
9. Reseeding, replanting with restoration of soil fertility.

MLRA 42; SD-2; Sandy

Black-grama dominated

•Black grama, soaptree yucca, dropseeds threeawns. No mesquite in immediate area.
•Black grama cover and stature is high
• Small patches of bare ground, covered with litter.
•Berino-Buckelbar map unit, Jornada Experimental Range, Dona Ana Co.

Shrub-invaded state

•Black grama, threeawns, snakeweed, few mesquite due to herbicide application
•Black grama cover and stature is low
• Large patches of bare ground, unprotected by litter and eroding.
•Wink-Harrisburg map unit, Jornada Experimental Range, Dona Ana Co.

Shrub-invaded state

•Dropseeds, threeawns, snakeweed, mesquite, black grama completely absent
•Grass cover very low, despite 40 yrs of grazing rest
• Note cryptogramic crust development and erosion around crusts.
•Hueco loamy sand, Fort Bliss, Otero Co..

Mesquite shrubland state,

•Snakeweed, some threeawns, many mesquite
•Grass cover very low
• Note evidence of wind erosion, litter accumulations in small depressions
•Wink Harrisburg map unit,
•Dona Ana Co., NM

Mesquite shrubland

•Mesquite, some snakeweed
•No grass cover in interdunes, some dropseeds associated with mesquite coppices
• Soil surface indurated and rich in carbonate, rills present.
•Copia-Nations complex, Fort Bliss, Otero Co., NM

The State Containing the Historic Climax Plant Community

Black grama-dominated grassland: The historic plant community is black grama dominated and dropseeds (*Sporobolus flexuosus, S. cryptandrus,* and *S. contractus*) may be secondary dominants. Bush muhly (*Muhlenbergia porteri*) and threeawns (*Aristida* spp.) are other common grasses. Soaptree yucca (*Yucca elata*), longleaf ephedra (*Ephedra trifurca*), and sand sage (*Artemisia filifolia*) are common shrubs. This state is defined by the capacity of black grama to persist indefinitely (e.g. some permanent quadrats on the Jornada Experimental Range). Through its high basal cover, high litter cover, and consequent low rates of erosion and high infiltration rates, black grama can regenerate by both seeding and tillering. Fires may or may not be frequent (see Overview: Information sources and theoretical background). If the climate hypothesis is correct, then this state may not now exist in SD-2, except during ephemeral periods of suitable climate. Mesquite is not able to mature in this state.

Retrogression within this state caused by grazing is characterized by an increasing relative abundance of dropseeds, threeawns, or snakeweed. It is also possible that in coarser soils, such as loamy sands, dropseeds dominate naturally. Two seasons without summer rains will also lead to black grama decline (Gibbens et al., in press), but grasses such as dropseeds and threeawns are thought to be more sensitive to drought than black grama (Herbel et al. 1972). Snakeweed or dropseeds may become dominant within this state due to grazing effects as long as the capacity of black grama to recover after cessation of grazing is not compromised. Gibbens and Beck (1987) and some unpublished records from the USDA-ARS Jornada Experimental Range, Las Cruces, NM provide evidence for recovery of black grama from dropseed dominance at a local scale (1 m^2). Campbell and Bombarger (1934) indicate that black grama can recover within snakeweed-dominated grassland.

Diagnosis: Black grama is very dominant and cover is continuous. There is evidence of black grama reproduction by seed and stolon. Large gaps (< 1 m) are very few. Litter cover is abundant. Soil stability values range from 4-6. There is no mesquite.

Ground Cover (Average Percent of Surface Area).	
Grasses & Forbs	16
Bare ground	73
Surface cobble and stone	0
Litter (percent)	10
Litter (average depth in cm.)	1

Plant Community Annual Production (by plant type):

Plant Type	Annual Production (lbs/ac) Low	RV	High
Grass/Grasslike	167	324	480
Forb	29	57	85
Tree/Shrub/Vine	29	57	85
Lichen			
Moss			
Microbiotic Crusts			
Totals	225	438	650

Historic Climax Plant Community Plant Species Composition: Plant species are grouped by annual production **not** by functional groups.

Group	Grass/Grasslike Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
1	black grama	*Bouteloua eriopoda*	88	131
2	spike dropseed	*Sporobolus contractus*	66	88
	sand dropseed	*Sporobolus cryptandrus*		
	mesa dropseed	*Sporobolus flexuosus*		
3	bush muhly	*Muhlenbergia porteri*	22	44
4	plains bristlegrass	*Setaria vulpiseta*	4	22
5	cane bluestem	*Bothriochloa barbinodis*	22	44
	Arizona cottontop	*Digitaria californica*		
6	tobosagrass	*Pleuraphis mutica*	4	22
7	threeawn	*Aristida*	22	44
8	Grass, annual		4	22
	blue grama	*Bouteloua gracilis*		
	fluffgrass	*Dasyochloa pulchella*		

Group	Shrub/Vine Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
9	longleaf ephedra	*Ephedra trifurca*	22	44
	yucca	*Yucca*		
10	sand sagebrush	*Artemisia filifolia*	4	22
	fourwing saltbush	*Atriplex canescens*		
	winterfat	*Krascheninnikovia lanata*		
	broom dalea	*Psorothamnus scoparius*		
11	pricklypear	*Opuntia*	4	13
12	broom snakeweed	*Gutierrezia sarothrae*	4	13

Group	Forb Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
13	croton	*Croton*	13	22
	buckwheat	*Eriogonum*		
	spurge	*Euphorbia*		
	globemallow	*Sphaeralcea*		
14	desert marigold	*Baileya multiradiata*	13	22
	spectacle pod	*Dimorphocarpa wislizeni*		
	filaree	*Erodium cicutarium*		
15	desert holly	*Acourtia nana*	4	13
	milkvetch	*Astragalus*		
	lambsquarters	*Chenopodium album*		
	tansymustard	*Descurainia sophia*		
	Russian thistle	*Salsola kali*		
	threadleaf groundsel	*Senecio flaccidus*		
	silverleaf nightshade	*Solanum elaeagnifolium*		
16	Forb, annual		4	22
	Forb, perennial			

Plant Growth Curve:
Growth Curve Number: NM2507
Growth Curve Name: HCPC
Growth Curve Description: SD-2 Sandy HCPC Warm Season Plant Community

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	10	10	25	30	15	5	0	0

Transition to black-grama limited state (1a): Climate change (see Information sources and theoretical background) or damage to black grama and loss of soil fertility by grazing, trampling, and moderate erosion may cause this transition. Gibbens et al. (in press) note that two summers without rain will kill black grama plants, so drought in combination with selective grazing on black grama may cause its extinction. Wright and Van Dyne (1976) note that the effects of cattle trampling may be more important than the effects of grazing per se. Furthermore, those authors found an effect of grazing on only loamy sands suggesting that relatively minor variations in soil texture may determine the sensitivity of black grama to grazing. Herrick et al. (2001) suggest that loss of litter cover, plant cover, and perhaps cryptogamic crust leads to soil degradation that creates an unfavorable environment for black grama. In particular, the loss of mycorrhizal fungi required by black grama may be an important mechanism (ongoing research by Laurie Abbott, NMSU, and Jerry Barrow, USDA-ARS Jornada Experimental Range). Increases in threeawns seem to be an especially ominous indicator of a transition, although it is unclear why. According to the review by Tirmenstein (1987), *Aristida purpurea* is favored by winter-spring precipitation, is animal dispersed, is disturbance-adapted, and is usually unpalatable. Thus, the variety of processes postulated to reduce black grama may all favor this grass.

Key indicators of approach to transition: Increases in bare ground, decreases in litter cover and black grama cover, decreased soil surface resistance to erosion, decreases in soil organic matter and microbiotic populations, increases in threeawns.

Transition to the shrub-invaded state (3a): Once shrubs invade and/or begin to grow to maturity, this transition has occurred. Many investigators believe that shrub invasion is initiated by reductions in black grama, but Herbel and Gibbens (1996) suggest that mesquite invasion can occur within apparently intact black grama stands. It is possible that the latter pattern emerges when the propagule load to an intact site is very high due its proximity to a mesquite-invaded site. Alternatively, mesquite propagules may usually be present as seeds but are able to achieve maturity in the absence of fire. If the competition hypothesis is true, loss of soil stability and selective herbivory on black grama with continued grazing may promote the growth and expansion of mesquite within this state. If the fire hypothesis is true, then the reduction of fire frequency associated with the loss of fine fuels is the cause for the transition. If the small animal shrub herbivory hypothesis is true, then the elimination or reduction of mesquite seedling predators is the cause, independent of grass cover. If none of these hypotheses are true, then once introduced, mesquite may expand despite cessation of grazing. It is likely that several of these processes work in parallel or in different instances.

Key indicators of approach to transition: Same as for transition 1a if the competition hypothesis is true. If the fire hypothesis is true then a reduction of black grama annual production and litter cover are indicators. If the dispersal hypothesis is true then there are no suitable indicators, other than the presence of potential seed vectors (i.e. livestock) and their connection to a seed source (a mesquite-invaded area).

Additional States

Black grama-limited grassland: Communities in this state may initially be structurally indistinguishable from the black grama-dominated grassland. If the climate hypothesis is correct, then black grama may dominate but will not show evidence of reproduction by seed and perhaps stolons, eventually leading to dominance by bunchgrasses. More typically, directional change via grazing or individual replacement will have already occurred, and black grama will be reduced to a subordinate component of the plant community. Snakeweed may also achieve dominance for long periods because it is less palatable than the grasses. Furthermore, once snakeweed attains a high density, some feel that allelopathic (Tirmenstein 1999) or competitive effects may inhibit the growth of grass populations. Jameson (1970), however, failed to document any competitive suppression of snakeweed on black grama. Climate (Campbell and Bombarger 1934), fire (McDaniel et al. 2000) and beetle herbivory (*Crossidius* spp.; Thompson et al. 1996) may regulate patterns of snakeweed abundance. Because snakeweed is a cool-season plant, it tends to increase in response to increases in winter-spring precipitation.

Black grama may persist in some locations through tillering if grazing does not drive the plant locally extinct. Following the drought of the 1950s, black grama basal cover increased from 1957-1977 on the Jornada Experimental Range but dropseeds often increased at a greater rate and became dominant or co-dominant (Herbel and Gibbens 1996). This pattern may be consistent with black grama reproductive limitation in this state, even though black grama cover may increase due to tillering. In either black grama or bunchgrass(snakeweed)-dominated communities, soil stability may be considerably lower than in the black-grama dominated grassland state. Mycorrhizal fungi that aid black grama establishment and survival may be a key component that is lost in this state.

<u>Diagnosis</u>: Black grama cover is usually lower than that of bunchgrasses, but total canopy cover may range from 60-75% where perennial grasses remain healthy. There is no evidence of black grama reproduction by seed and stolon production. The % of continuous line intercept that is gap >1 m may range from 37-56. Average surface soil stability values range from 3.5-5, subsurface (2.5 cm) values are 1.3-2. Mesquite is absent or rare (data from Herrick et al. unpublished).

Transition to bunchgrass grassland (2): This is caused by the local extinction of black grama due to grazing, loss of soil fertility, drought, or other disturbance.

<u>Key indicators of approach to transition</u>: Decadence of black grama, pedestalling or sand burial of black grama plants, lack of reproduction.

Transition to shrub-invaded grassland (4a): Mesquite propagules may be introduced to a system some time after black grama reproduction has become limited and/or black grama dominance declines. Environmental conditions are likely to be suitable for mesquite establishment within the black-grama limited state. Thus, only the presence of a mesquite-seed vector is required for this transition to take place.

<u>Key indicators of approach to transition</u>: There are no suitable indicators, other than the presence of potential seed vectors (i.e. livestock) and their connection to a seed source (a mesquite-invaded area).

Transition to black grama-dominated grassland (1b): Black grama has been observed to survive in certain patches on the Jornada Experimental Range through the drought periods (Gibbens et al., in press). Understanding what properties distinguish these patches from areas where black grama has declined may hold important clues to preventing grassland degradation and restoring black grama. Methods for reversing the transition are currently unknown, and might require restoration of soil fertility.

***<u>Bunchgrass grassland</u>*:** This state is characterized by a lack of black grama and dominance by bunchgrasses (threeawns or dropseeds) or snakeweed.

<u>Diagnosis</u>: Absence of black grama plants. Mesquite is absent or rare.

Transition to shrub-invaded grassland (5a): As for transition 4a above.

Transition to black grama-dominated grassland (9): Restoration techniques are unknown, but may require soil stabilization, restoration of soil fertility, and reintroduction black grama seeds.

Shrub-invaded grasslands: Communities in this state can be distinguished from either black grama-dominated, black grama-limited, or bunchgrass grasslands by the presence of honey mesquite. In some cases, mesquite can invade otherwise healthy-looking black grama grassland that may catalyze or co-occur with events leading to black grama loss. In other cases, mesquite has invaded after significant black grama degradation has occurred and bunchgrasses may coexist with mesquite over the long term. It is believed that black grama loss (**transition 6a**) and possibly a transition to mesquite dunes (**transition 7**), eventually occurs without grazing rest and shrub control (e.g. Hennessy et al. 1983).

Mesquite plants may be very small and difficult to detect. Although fire may kill small (< 1.5 yr old; Wright et al. 1976) mesquite, it is unlikely that fire frequencies will be sufficiently high to remove mesquite from a grassland once a source of mesquite propagules has been connected to a grassland. It is possible that mesquite seedlings are a normal component of black-grama dominated grassland but are suppressed by fire, small mammal herbivory, and/or competition in the black grama-dominated state (Brown and Archer 1999). Through either the exogenous effects of climate change or disturbance, or the endogenous effects of mesquite dominance, it is most common to observe a reduction in black grama reproduction coincident with mesquite increase (bunchgrasses/mesquite). There are no data available that relate grass reproduction to levels of invasion. Valentine (1936), however, indicates that beyond a height of 1-2 feet, mesquite begins to exclude grasses from around plant bases although it is unclear why. Mesquites may provide cover and nest sites for rodents (e.g. kangaroo rats) and lagomorphs (jackrabbits, cotton-tails) that increase herbivory on black grama adults and seedlings (ongoing research, Deb Peters and Brandon Bestelmeyer, USDA-ARS Jornada Experimental Range). If black grama reproduction is limited, it may be rapidly extirpated with grazing and interactions with shrubs and only bunchgrasses may remain to maintain soil stability. Within this state, brush control using herbicides (e.g. 2,4,5-T) resulting in at least a 30% mesquite kill can result in increases in grasses (Herbel et al. 1983).

On soils with > 5% gravel content, creosotebush (*Larrea tridentata*) may invade as well.

Diagnosis: Mesquite are present and usually conspicuous. Total basal cover may range from 5.3-9.3 due to mesquite. Canopy cover may range from 17-35%. Black grama cover may be substantial with areas around shrubs devoid of grass (Black grama/mesquite), or it may be rare to absent (bunchgrasses/mesquite). The % of continuous line intercept that is gap >1 m ranges from 76-90. Average surface soil stability values range from 1.4-2.5, subsurface (2.5 cm) values are 1.1-1.7. This state is very common in SD-2 (e.g. the College Ranch and Jornada Experimental Range sandy sites near Las Cruces, NM).

Transition to bunchgrasses-mesquite state (6): Grazing, drought, rodent activities, and competition with shrubs may drive black grama to a subordinate status or extinct. Alternatively, this transition may occur solely due to processes associated with the presence of mesquite, and thus will eventually occur unless mesquite are removed.

Key indicators of approach to transition: Decadence of black grama, pedestalling of black grama plants, lack of reproduction.

Transition to mesquite shrubland state (7): This transition results in the largest change in ecosystem functioning in the Sandy site. Once grass cover is reduced below some amount and/or soil-surface disturbances due to cattle trampling reduce soil surface stability and infiltration, eolian and sheet erosion will create a transition to the mesquite shrubland state. The factors responsible for the apparently great variation in the thresholds for this transition are unknown. On Fort Bliss, one factor may be variation in landscape position (Fig. 1). The depression receives run-in water and eroded soil causing the carbonate zone to be covered by a thicker mantle of soil (Gile and Grossman 1997). Meanwhile, soil is eroding from the higher surfaces. After erosion, the carbonate-rich hardpan developing on the higher surfaces inhibits infiltration and causes a transition to mesquite coppice dunes (caused by collection of erosional material) with bare interdunes (hardpan surface). Deeper carbonate (no hardpan) due to soil accretion supports dropseeds, sand sage, soaptree yucca in the depression, despite drought and overgrazing.

In other cases, grasses cannot colonize interdunes due to the instability of the substrate, high sub-soil temperatures (Hennessy et al. 1983), or low nutrient availability. Rodent and rabbit herbivory on grass seedlings provides another explanation for the inability of grasses to establish in interdunes or on dunes where nutrients or other physical factors are not limiting.

In some cases, mesquite does not dominate and erosion to B horizons (e.g. sandy clay loams) leads to dominance by snakeweed and saltbush (*Atriplex canescens*).

Key indicators of approach to transition: Continued loss of grass cover, biotic soil crusts, and evidence of increased bare ground and erosion (e.g. the accumulation of caliche chunks and stones at the surface) indicate movement toward threshold. Pedestalling, blowouts, ripples in sand, soil surface loss will be evident.

Transition to black grama-dominated, limited, or bunchgrass grassland (3b, 4b, 5b): Mesquite removal by application of herbicides, grass recovery and recovery of suitable fuel loads, and reinitiation of historic fire frequencies if the fire hypothesis is true. Attention to fuel load, continuity, and fire timing and frequency may be important if fire prevented mesquite expansion. The successful use of fire in black grama grasslands, however, depends strongly upon the size of mesquite and probably on post-fire precipitation patterns that favor black grama recovery (Drewa and Havstad 2001). At this point, it is unclear if fire can be effectively used as a management tool to promote black grama dominance. If the competition hypothesis is true, then simply reestablishing grass cover would be sufficient. Both of these approaches are unlikely to be supported in black-grama limited or bunchgrass grasslands, which generally exhibit low production and cover. If climate or mesquite seed availability alone is responsible for transitions 3a, 4a, or 5a, transitions to grasslands may be impossible to bring about.

***Mesquite shrubland*:** Continued reduction of grasses, or invasion of snakeweed dominated areas by mesquite, accelerates eolian and sheet erosion, reducing soil fertility in shrub interspaces and redistributing nutrients to the bases of shrubs (see the nutrient redistribution hypothesis in Overview: Information sources and theoretical background). Eventually, much of the soil A horizon is removed from shrub interspaces and a hardpan B horizon may be exposed there. Grass (or shrub) establishment on this surface may be impossible. Soil accumulates around the bases of shrubs coincident with the deflation of soil in shrub interspaces. This process results in the formation of coppice dunes (or *nabkas*; Langford 2000). The soils formed upon dunes are more or less homogenous to depths of meters and are often classified as Pintura soils in Doña Ana County and Copia soils on Fort Bliss. This soil classification has prompted some investigators to refer to these dunes as Deep sand ecological sites. Deep sand sites occur naturally and support a distinct plant community, so it is preferable to consider recently-formed coppice dunes as a community within the mesquite shrubland state, or perhaps a new ecological site. Dropseeds and snakeweed may or may not occur in the interdunes depending upon the depth to a restrictive layer. Often, grasses (mostly bush muhly and dropseeds) and other shrubs, especially saltbush, colonize dunes because of the greater availability of water there (Hennessy et al. 1985). Creosotebush may also dominate these shrublands where gravel content is high, although they tend not to form large coppice dunes.

<u>Diagnosis</u>: Mesquite is dominant. It often eventually forms coppice dunes from 0.5-3 m high (depending on depth to caliche) in the latter stages of development. Black grama and bunchgrasses may be absent and if present are often restricted to dunes. Snakeweed and a few bunchgrasses may occur in interdunes if an impermeable horizon has not been exposed. There is often evidence of eolian soil erosion including pedestalling, sand ripples and an exposed, dark grey B horizon in interdunes.

Transition to bunchgrass grassland (8): In principle, it may be possible to kill mesquite, redistribute or add soil nutrients, and stabilize soil during periods favorable to the germination of bunchgrasses, perhaps in conjunction with seeding. The use of municipal biosolids may aid in restoring soil fertility (Walton et al. 2001).

Information sources and theoretical background: Communities, states and transitions are derived largely from the literature including Buffington and Herbel (1965), Herbel et al. (1972), Gibbens and Beck (1987), Hennessy et al. (1983), and Herbel and Gibbens (1996). Communities are usually defined by the primary and secondary dominant plant species, but sometimes emphasize dominant species of differing life-forms or subordinate species that indicate particular processes. Mechanisms underlying transitions are derived from the literature and expert opinion and are founded upon seven hypotheses.

The *climate hypothesis* states that the regional climatic conditions that favored black grama establishment in past centuries, featuring dry winters followed by wet summers, are currently rare (Neilson 1986, Brown et al. 1997). Thus, site potential has changed at a regional scale, transitions from black grama-dominated communities to shrub-dominated ones are inevitable, and disturbances to black grama, reduction of fire, and introductions of shrub propagules (Brown and Archer 1999) only accelerate the process of replacement.

A second set of alternative hypotheses are based on the notion that regional climate does not preclude the regeneration of grasslands (although it may not favor it), but that disturbance to grasses and soils due to a synergistic combination of grazing and episodic drought has created a window of opportunity for shrub establishment and eventual dominance. The *competition hypothesis* holds that grassland maintenance depends upon the competitive exclusion of shrub seedlings due to limitations in water or nutrients (Van Auken and Bush 1990, but see Brown and Archer 1999). There may be a threshold grass density below which the probability of shrub establishment increases rapidly, leading to a transition to the shrubland type. The *fire hypothesis* holds that frequent fires prevent shrub establishment or growth to maturity in healthy grasslands. If fine fuels produced by grass are reduced below a threshold amount, there may be insufficient fuel to carry fire, or insufficient heat from fire to kill shrubs (Wright et al. 1976). According to this hypothesis, shrubs are better competitors than grasses and can come to dominate grasslands without disturbance. A related explanation, the *small animal shrub herbivory hypothesis*, holds that extirpation of shrub seedling herbivores, such as prairie dogs (*Cynomys* spp.) released mesquite from herbivory pressure and allowed it to express its competitive dominance (Weltzin et al. 1997; and see Gibbens et al. 1992). A null hypothesis to these explanations is the *shrub dispersal hypothesis*. In this scenario, the only factor limiting the establishment and eventual dominance of mesquite is a suitable dispersal agent, with or without reduction of grasses and soil disturbance (Brown and Archer 1987).

Once shrubs become established, the *nutrient-redistribution hypothesis* explains the processes that lead to the eventual dominance of mesquite and loss of grasses. This explanation holds that there is a positive feedback between plant life forms and the relative availability of nutrients to those life forms (Schlesinger et al. 1990, Ludwig et al. 1994). Self-sustaining grasslands effectively capture resources that are converted into grass biomass (Ludwig et al. 2000). Once grass cover is reduced below a threshold amount, surface soil degradation due to erosion, loss of organic matter, and physical crusting reduces the infiltration of water and accelerates the reduction of available mineral nutrients and water (Herrick et al. in press). This sets in motion a distinct positive feedback relationship in which infiltration and nutrients become increasingly concentrated under shrubs due to increased erosion from shrub interspaces, deposition of soil at the bases of shrubs, and water interception by shrub leaves and stemflow to shrub roots (Schlesinger et al. 1990, Schlesinger et al. 1998). This favors shrub maintenance and establishment at the expense of (or relative to) grasses. Grass reestablishment in shrub interspaces is precluded by the lack of available nutrients. Studies have, however, failed to detect a loss of plant-available soil water in interdunes (Herbel and Gibbens 1987, Hennessy et al. 1985) or a loss of organic matter (Hennessy et al. 1985).

An additional hypothesis addresses the maintenance of shrublands, although it is unclear how it relates to shrub establishment. The *small animal grass herbivory hypothesis* holds that once shrubs have invaded, the reestablishment of grasses is inhibited due to the activities of rodents, rabbits, or insects. In contrast to the nutrient-redistribution hypothesis, grass seedlings may be capable of establishment in the shrub interspace environment were it not for the activities of small animals (Campbell 1929). Small mammal abundance may be favored in shrublands (Whitford 1997, David Lightfoot, unpublished data) and small mammals may have a disproportionately large impact on grass seedlings in shrublands due to increased herbivore abundance and/or to the increased apparency or desirability of the seedlings to herbivores.

It is likely that these processes interact to create threshold changes from grasslands to shrublands. Different processes embodied in the hypotheses may be important at different stages of grassland loss, or vary in importance from place to place. Beyond these general conceptual developments, there have few attempts to evaluate these hypotheses in specific instances in the SD-2 ecological sites or to quantify values in proximate or indicator variables underlying the proposed processes. Thus, despite a rich history of research on these topics, few results can be directly applied to the identification of key thresholds.

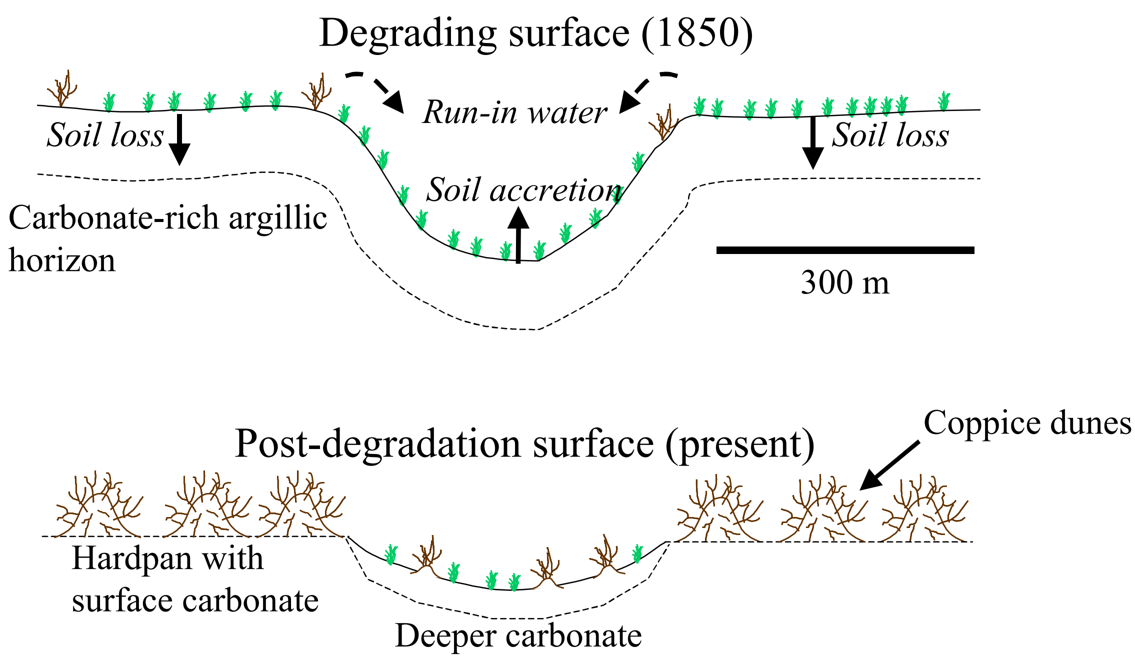


Figure 1. One hypothesis explaining variation in the transition from the grassland state to the mesquite shrubland state on the Sandy ecological site. Overgrazing and drought catalyze erosion. The depression receives run-in water and eroded soil causing carbonate zone to be covered by a thicker mantle. After erosion, the carbonate-rich hardpan underlying the higher surface inhibits infiltration and causes a transition to mesquite coppice dunes (caused by collection of erosional material) with bare interdunes (hardpan surface). Deeper carbonate (no hardpan) due to soil accretion supports grasses in the depression, despite drought and overgrazing.

Ecological Site Interpretations

Animal Community:
This site provides habitat which supports a resident animal community that is characterized by prong horn antelope, badger, kit fox, desert cottontail, spotted ground squirrel, desert pocket gopher. desert pocket mouse, ord dangaroo rat, southern plains woodrat, western meadow lark, scaled quail, pyrrhuloxia, roadrunner, burrowing owl, New Mexico whiptail lizard, round tailed horned lizard and Couchs spadefoot toad. Where Large mesquite, yucca and cholla cactus are present, this site is a breeding area for Swainsons hawk. mockingbird, Scotts oriole, mourning dove and white necked raven. When site deterioration produces a dune interdune aspect with mesquite invasion, animal populations shift in favor of burrowing mammals, their predators and shrub dependent birds.

Hydrology Functions:

The runoff curve numbers are determined by field investigations using hydraulic cover conditions and hydrologic soil groups.

Hydrologic Interpretations	
Soil Series	Hydrologic Group
Cacique	C
Wink	B
Berino	B
Dona Ana	B

Recreational Uses:
Suitability for camping and picnicking is fair, and hunting is fair for pronghorn antelope, quail, dove, and small game. Photography and bird-watching can be fair to good, especially during migration seasons. Most small animals of the site are nocturnal and secretive, seen only at night, early morning or evening. Scenic beauty is greatest during spring and sometimes summer months when flowering of forbs, shrubs, and cacti occurs.

Wood Products:
None

Other Products:
Grazing:

This site, at its potential, is suitable for grazing in all seasons of the year. Green forage in the form of annual forbs and a few early-season grasses is produced to some extent in the spring. The dominant production comes at the beginning of July and runs through September. The site is suitable for cattle, especially crossbreeds bred to withstand high summertime temperatures and long walks to water, and to sheep, goats, and horses. Site deterioration caused by inadequate grazing management is characterized by a decline in black grama and an increase in dropseeds, threeawns, and eventually invasion by mesquite. As retrogression takes place, hummocking may occur and brush control may be needed to effect a reasonable rate of recovery.

Other Information:	
Guide to Suggested Initial Stocking Rate Acres per Animal Unit Month	
Similarity Index	Ac/AUM
100 - 76	3.8 – 5.0
75 – 51	4.5 – 6.5
50 – 26	6.0 – 10.5
25 – 0	10.5+

Plant Preference by Animal Kind:

	Code	Species Preference	Code
Stems	S	None Selected	N/S
Leaves	L	Preferred	P
Flowers	F	Desirable	D
Fruit/Seeds	F/S	Undesirable	U
Entire Plant	EP	Not Consumed	NC
Underground Parts	UP	Emergency	E
		Toxic	T

Animal Kind: Livestock

Animal Type: Cattle

Common Name	Scientific Name	Plant Part	Forage Preferences											
			J	F	M	A	M	J	J	A	S	O	N	D
sand sagebrush	*Artemisia filifolia*	L	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
fourwing saltbush	*Atriplex canescens*	EP	P	P	P	P	P	D	D	D	D	D	P	P
cane bluestem	*Bothriochloa barbinodis*	EP	D	D	D	D	D	P	P	P	D	D	D	D
black grama	*Bouteloua eriopoda*	EP	P	P	P	D	D	D	D	D	D	D	P	P
blue grama	*Bouteloua gracilis*	EP	D	D	D	D	D	P	P	P	P	P	D	D
redstem stork's bill	*Erodium cicutarium*	EP	N/S	P	P	P	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
winterfat	*Krascheninnikovia lanata*	P	P	P	P	P	P	D	D	D	D	P	P	P
bush muhly	*Muhlenbergia porteri*	EP	P	P	P	P	P	P	P	P	P	P	P	P
tobosa	*Pleuraphis mutica*	EP	N/S	N/S	D	D	D	P	P	P	D	D	D	N/S
plains bristlegrass	*Setaria vulpiseta*	EP	D	D	D	D	D	P	P	P	P	D	D	D
spike dropseed	*Sporobolus contractus*	EP	U	U	U	D	D	D	D	D	D	U	U	U
mesa dropseed	*Sporobolus flexuosus*	EP	U	U	U	D	D	D	D	D	D	U	U	U
soaptree yucca	*Yucca elata*	F	N/S	N/S	N/S	N/S	P	P	N/S	N/S	N/S	N/S	N/S	N/S

Supporting Information

Associated Sites:

Site Name	Site ID	Site Narrative
Deep Sand 8 to 10.5 inches	R042XB011NM	
Shallow Sandy 8 to 10.5 Inches	R042XB015NM	

Similar Sites:

Site Name	Site ID	Site Narrative
Deep Sand 8 to 10.5 inches	R042XB011NM	
Shallow Sandy 8 to 10.5 Inches	R042XB015NM	

State Correlation:
This site has been correlated with the following states: Texas

Inventory Data References:

Data Source	Number of Records	Sample Period	State	County

Type Locality:
Jornada Experimental Range

Relationship to Other Established Classifications:

Other References:
Data collection for this site was done in conjunction with the progressive soil surveys within the Southern Desertic Basins, Plains and Mountains, Major Land Resource Areas of New Mexico. This site has been mapped and correlated with soils in the following soil surveys. Sierra County Dona Ana County Grant County Hidalgo County Luna County Otero County

Characteristic Soils Are:	
Cacique fine sandy loam	Dona Ana fine sandy loam
Wink fine sandy loam	Harrisburg loamy fine sand
Berino fine sandy loam	Bucklebar fine sandy loam, sandy loam
Other Soils included are:	
Wink loamy fine sand, less than 5"thick surface	Sonoita loamy fine sand, loamy sand
Cacique loamy fine sand	Hueco loamy fine sand, less than 5"thick surface
Onite loamy fine sand	Bucklebar loamy fine sand
Pajarito fine sandy loam	Continental sandy loam

Site Description Approval:

Author	Date	Approval	Date
Don Sylvester	07/12/1979	Don Sylvester	07/12/1979

Site Description Revision:

Author	Date	Approval	Date
Dr. Brandon Bestelmeyer	05/22/02	George Chavez	05/22/02
George Chavez	05/22/02		